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Private Industry Investing Heavily, and Globally, in Research To Improve Agricultural Productivity

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- In 2010, global private-sector investments in research and development (R&D) to improve agricultural inputs reached $11.0 billion, up from $5.6 billion in 1994.
- R&D spending as a share of product sales exceeded 7 percent in the industries supplying crop protection chemicals, crop seed and biotechnology traits, animal health products, and animal breeding and genetic inputs to agriculture.
- Many of the leading agricultural input firms have located R&D facilities around the world; this globalization may accelerate the rate of international technology transfer.

Over the past several decades, private-sector firms have become major players in developing new innovations for agriculture worldwide. The emergence of biotechnology and other scientific developments, the strengthening of intellectual property rights (IPR) over agricultural innovations, the global expansion of markets for agricultural inputs, and changing government regulations are some of the factors driving private companies to invest in agricultural research. A recently completed ERS study provides, for the first time, detailed information on global research and development (R&D) spending in seven agricultural input sectors—crop seed and biotechnology, crop protection chemicals, synthetic fertilizers, farm machinery, animal health, animal breeding and genetics, and animal nutrition, focusing on the 1994-2010 period. Findings show that private-sector R&D expenditures in input industries increased by more than 40 percent in real (inflation-adjusted) dollars over the period.

Global Market for Agricultural Inputs

Firms supplying inputs to the agricultural sector invest in R&D to develop or improve their products with the aim of increasing or maintaining sales and earning a profit. The expense and risk associated with R&D require firms to align these investments carefully with anticipated market trends and opportunities. When planning R&D, market size is one consideration that varies widely across agricultural input markets. In 2006, animal nutrition was the largest single input sector, with an estimated $142 billion in global sales consisting mostly of manufactured feed, feed concentrates, and nutritional feed additives (a related type of input, medicated feed, was included in the animal health sector). This market was nearly twice the size of the next largest input markets—farm machinery and crop fertilizers.

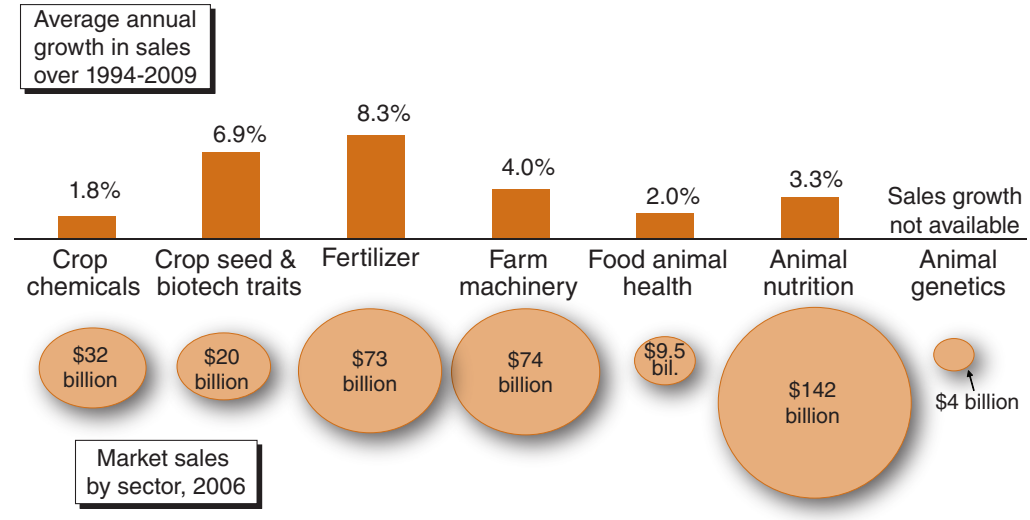
Firms planning R&D also consider the anticipated growth of markets, new technological opportunities for product improvements, and competition from other firms. Within the crop input sectors, average annual growth in global input sales during 1994-2010 was highest in the fertilizer market, mainly due to rising prices. Over the same period, growth in commercial sales of crop seed and biotechnology traits was also high, particularly after widespread commercial release of genetically modified (GM) seed in the late 1990s. On the other hand, sales of crop protection chemicals grew more slowly as the introduction of GM seeds increased demand for some herbicides but reduced demand for other herbicides and some insecticides. Producers of crop protection chemicals with expiring patents also faced greater competition from generic versions of these products.

Private-Sector Investment in Agricultural Research

Total private R&D expenditures in the seven agricultural input sectors combined increased from $5.6 billion in 1994 to $11 billion in 2010—an average annual growth rate of 3.6 percent (or, in inflation-adjusted dollars, by 1.4 percent per year). Crop improvement accounted for most of the increase in R&D spending between 1994 and 2010, with inflation-adjusted R&D spending in the animal-related inputs remaining essentially flat. The most rapid growth in agricultural R&D over 1994-2010 was for crop seed and biotechnology traits. Seed-biotechnology research expenditures grew particularly fast in the 1990s and between 2007 and 2010. By 2008, they surpassed research expenditures in crop protection chemicals for the first time. Farm machinery research also increased substantially, with much of the growth occurring since 2006. Part of this change reflects rising demand for farm mechanization, and part is in response to more stringent regulatory requirements on farm vehicle exhaust emissions in the United States.

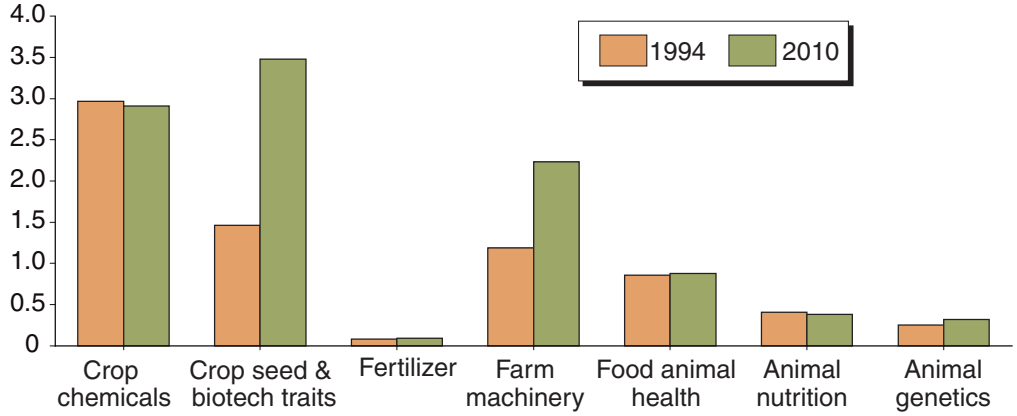
Among all countries, the United States was the leader in private agricultural R&D during 1994-2010, accounting for over one-third of the global total. U.S. companies were particularly dominant in the crop seed/biotechnology and animal breeding/genetic sectors, where they made up about half of global private R&D investments. European firms accounted for about half of total R&D across all agricultural input industries over the period, with companies based in Germany, Switzerland, and the Netherlands being the leaders in this region. Japan led private R&D in the Asia-Pacific

Global markets for agricultural inputs vary in size and rate of growth



Source: USDA, Economic Research Service.

Most growth in private agricultural research spending has occurred in the crop seed/biotechnology and farm machinery sectors



Source: USDA, Economic Research Service.

region. Worldwide, Japanese firms were among the leaders in crop protection chemicals and farm machinery R&D.

Where the Private Sector Fits in the Global Agricultural Research System

How does private R&D investment stack up with public-sector expenditures on agricultural research? Comprehensive global estimates of government agricultural R&D spending are available only for the year 2000, based on research by Beintema and Stads. When these data are combined with ERS data on private-sector spending in 2000, the private sector accounted for 45 percent of total food and agricultural R&D spending worldwide. Although the global estimates of public research spending do not separate food from agricultural R&D, the U.S. data may be illustrative, at least for high-income countries. According to USDA's Inventory of Agricultural Research, in 2000, about 60 percent of total U.S. public agricultural R&D was allocated to research related to plant and animal systems; 15 percent went to food and human nutrition; and 24 percent went to environmental and other issues not directly related to food or farm production. If these figures are representative of public agricultural R&D in high-income countries, it would imply that the private sector accounts for roughly 46 percent of total production agriculture research and 76 percent of food-related research in these countries. In both the agricultural and food sectors, public research and private research tend to be complementary, with public research focusing on more basic sciences or on technologies where market incentives are weak (e.g., science and technology to conserve environmental resources and improve food nutrition and safety).

Agricultural Input Markets Differ in Research Intensity

How does private R&D spending match up with the size and growth of agricultural input markets? Among agricultural input industries, *research intensity*, or research spending as a percentage of market sales, varies widely. Generally, R&D intensity within each sector remained fairly constant between 1994 and 2009 (data from 2010 on sales for all input sectors are not yet available). The most R&D-intensive sector was crop seed/biotechnology. In this sector, R&D intensity was particularly high in the late 1990s and early 2000s when many new GM crop varieties were being commercialized. More recently, research intensity has declined somewhat but was still over 10 percent of the value of annual seed sales in 2009. Research intensities in the next two highest sectors—crop protection chemicals and animal health—were somewhat lower, about 8 percent per year. The crop protection chemicals sector has been heavily affected by changes in government regulations governing the health, safety, and environmental impacts of new and existing pesticide formulations. A rising share of R&D spending in the sector has gone toward meeting these regulatory requirements, and, as a result, a smaller share has gone to new chemical discovery.

Several factors account for variations in research intensity across agricultural input sectors and over time. In addition to market size and growth, these include opportunities provided by scientific advances to develop new technology; the ability of developers to capture economic gains from intellectual property; rising (or falling) availability of agricultural resources; the cost of science and technology inputs used in

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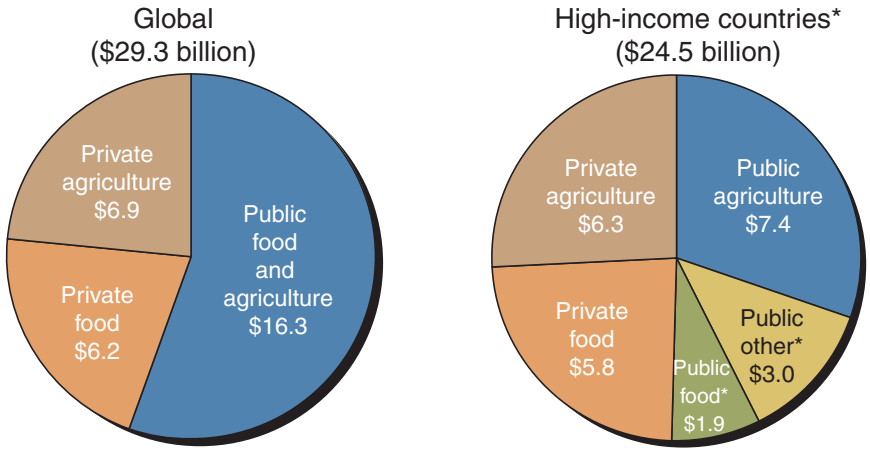


*Assumes breakdown of U.S. public food and agricultural R&D roughly reflects allocation of public R&D in other high-income countries as well.

Source: USDA, Economic Research Service using data from Beintema et al., *Measuring Agricultural Research Investments: A Revised Global Picture*, ASTI Background Note, Agricultural Science and Technology Indicators, International Food Policy Research Institute, 2008.

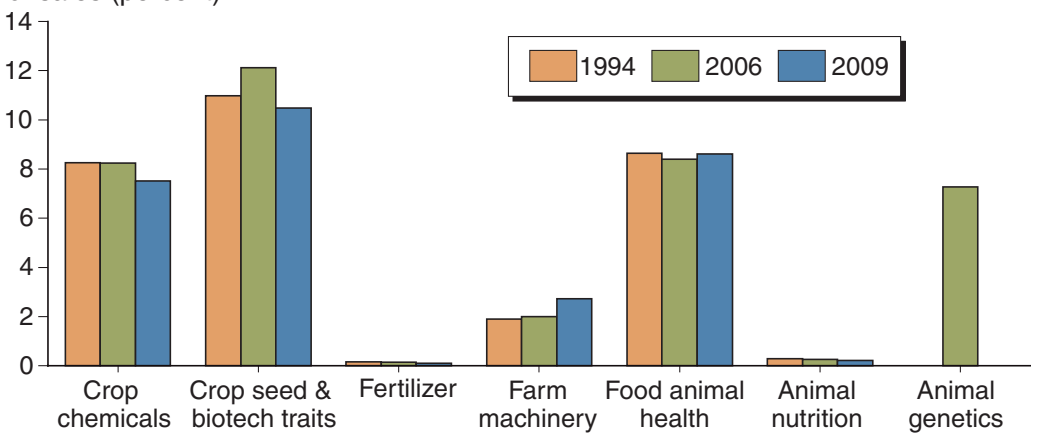
research; and the regulatory costs of commercializing new technologies. Advances in molecular genetics and stronger intellectual property protection over biological discoveries have increased incentives for the private sector to invest in crop and animal breeding and genetics research. Rising wages and the migration of farm labor to cities in many parts of the world have increased demand for farm mechanization, strengthening incentives for private R&D into new kinds of farm machinery. Even though the markets for fertilizer and animal nutrition are relatively large, profit margins are low and manufacturers lack incentives to invest much in research and innovation in these products (an exception is animal nutritional supplements; manufacturers of these products typically spend around 2-4 percent of sales revenues on research).

Not only do sectors differ in their research intensity, but companies within a sector also differ in their focus on research. Based on average research intensity for companies in three of the agricultural input sectors, larger companies generally spend a larger share of their market sales on research. "Discovery" companies invest heavily in screening new chemical, biological, and pharmaceutical compounds for useful traits that can be patented and developed commercially. These are often large companies with hundreds of millions of dollars in annual product sales. The largest of these companies in the crop chemical, seed and trait, and animal health industries invest 9 percent or more of their annual product sales in research. "Second-tier," or midsized, companies in these industries typically invest somewhat less in research, around 7 to 8 percent of annual sales. Smaller companies spend an average of 2 to 4 percent of annual sales on formal research, much of which is to cover regulatory and testing costs of bringing new off-patent products and product formulations to market, rather than new product discovery. Small agricultural biotechnology companies are an exception, often being heavily focused on research despite their size. These highly research-intensive, "startup" companies seek to commercialize new scientific discoveries or provide larger firms with specialized technical services. Funded through venture capital, "angel investors," equity investments by large firms, and initial stock market offerings, many of these high-risk ventures fail. Successful startups are often subsequently acquired by larger firms. While their overall R&D spending is relatively small, these firms are an important source of new innovations.

Private Agricultural R&D: Going Global

All of the leading firms and many of the second-tier firms in the agricultural input industries are multinational, marketing products across several continents. In 2006, member countries of the North American Free Trade Agreement (NAFTA—United States, Canada, and Mexico) accounted for about 23 percent of the global seed market and 30-36 percent of global sales of crop protection chemicals, farm machinery, animal feed, and animal health pharmaceuticals (including those for nonfood animals). The Europe-Middle East-Africa market (which is mostly Europe) had the largest aggregate seed sales in

Research spending as a share of sales is highest in the crop seed/biotechnology, crop chemical, animal health, and animal breeding/genetics sectors



Source: USDA, Economic Research Service.

With the exception of small and medium-size biotechnology companies, larger firms invest a greater share of sales in research

Sector	Size of firms	Research/sales *(percent)*
Crop chemicals		
	Large discovery companies (>$2 billion sales)	9.0
	Second-tier discovery companies (<$2 billion sales)	7.3
	Other manufacturers	2.3
Crop seed and biotechnology traits		
	Large seed companies (> $600 million sales)*	15.8
	Midsize seed companies ($50 million-600 million sales)	7.3
	Other seed companies	2.0
	Small agricultural biotechnology companies	42.1
Animal health		
	Large animal health discovery companies (>$800 million in sales)	10.0
	Midsize animal health companies ($250 million-$800 million sales)	7.6
	Other manufacturers	3.8

*Several of the large crop chemical discovery companies (BASF, Bayer, Syngenta, Dupont, and Dow) are also large seed and biotechnology trait discovery companies. Although BASF (a large German biochemical firm) has few direct seed sales, we include it with the large seed company category because it invests heavily in crop biotechnology.

Source: USDA, Economic Research Service using USDA's 2005 and 2009 Agricultural Resource Management Survey.

2006, whereas Asia-Pacific countries used the most fertilizers and bought the most farm machinery. Together, the shares of Asia-Pacific and Latin America give a rough estimate of the developing-country share of global agricultural input markets (sales in Africa, also a developing region, are relatively small and not reported separately). In 2006, these regions accounted for 37-51 percent of global sales of crop seed and chemicals, farm machinery, fertilizers, and animal feed. Global trade in agricultural inputs has also grown rapidly over the past two decades. Between 1990 and 2007, international trade in animal breeding material grew by 260 percent, and trade in farm machinery grew by 190 percent (in constant U.S. dollars). Trade in crop protection chemicals and crop seed also grew over the period (trade statistics for animal health products are not available).

Because the performance of agricultural technologies tends to be site specific due to variations in weather, soil type, and other environmental conditions, many of the leading agricultural input firms have located R&D facilities around the world. In addition, they may operate experimental and testing stations in many other subsidiary locations and countries. This global R&D presence not only enables firms to develop and adapt new technologies to regional conditions and more easily meet local regulatory requirements, but it may also allow them to achieve cost economies in some R&D activities (that is, by conducting certain kinds of research in countries where highly trained personnel or specialized R&D services can be hired more cheaply).

This article is drawn from . . .

Research Investments and Market Structure in the Food Processing, Agriculture Input, and Biofuel Industries Worldwide: Executive Summary, by Keith O. Fuglie, Paul Heisey, John King, Kelly Day-Rubenstein, David Schimmelpfennig, and Sun Ling Wang, EIB-90, USDA, Economic Research Service, December 2011, available at: www.ers.usda.gov/publications/eib90/

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